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Preventive Medicine 42 (2006) 85 – 95
Preventive Medicine
www.elsevier.com/locate/ypmed

Getting children to eat more fruit and vegetables: A systematic review

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Available online 20 December 2005

Abstract

Background. There is growing recognition of the need to increase consumption of currently suboptimal levels of fruit and vegetables by children, given their known beneficial effects for health. There is, however, a need for a synthesis of the evidence on interventions that might achieve this policy goal.

Methods. A systematic review of published and unpublished studies was carried out by searching 14 publication databases and contacting experts in the fields. All papers in eight languages were considered if they described individual- and population-based interventions and promotion programmes that encouraged the consumption of a diet relatively higher in fruit and/or vegetables in free-living, not acutely ill children of both genders, with follow-up periods of at least 3 months, measurement of change in intake and a control group.

Results. Fifteen studies focusing on children met the criteria for inclusion in the systematic review. None of the studies reviewed had a detrimental effect on fruit and vegetable consumption. Ten studies had a significant effect, ranging from +0.3 to +0.99 servings/day.

Conclusions. More research is needed to examine in more depth, for longer follow-up periods, the effectiveness of interventions promoting fruit and vegetable consumption. The evidence is strongest in favor of multi-component interventions to increase fruit and vegetable consumption in children.

Keywords: Review; Fruit; Vegetables; Child; Randomized controlled trial; Education; Counselling

Introduction

The most recent evidence for the importance of nutritional factors in preventing disability and death in Europe suggests that 4.4% of the overall burden of disease in the region could be attributed to low fruit and vegetable intake (WHO, 2002). Fruit and vegetables are important sources of a wide range of vital micronutrients, and there is now strong evidence that fruit and vegetable consumption can prevent a number of chronic non-communicable diseases including cardiovascular disease and some cancers (IARC, 2003; Klerk et al., 1998; Robertson et al., 2004; WCRF/AICR, 1997; WHO, 2003). Although most of the research on this association has focused on adults, some studies have examined the influence of childhood diet on disease in later life, such as a recent follow-up of the Boyd Orr cohort, initiated in the 1930s (Gunnell et al., 1996; Rowett, 1955), which found that childhood fruit consumption appeared to be protective against cancer in adulthood (Maynard et al., 2003). There is also growing evidence that fruit and vegetable consumption in children may protect against a range of childhood illnesses. In a study of over 20,000 children in six Central European countries, an association was found between respiratory symptoms and low fruit and vegetable consumption (Antova et al., 2003).

While evidence for the public health benefits of consuming more fruit and vegetables grows, nutritional surveys show that children and adults in most regions of the world are not meeting the minimum suggested consumption goals of 400 g/day (Health Behaviour in School-aged Children (HBSC) study, 2001; Pomerleau et al., 2004; WHO, 2003). Furthermore, children and adolescents are particularly at risk because of their often erratic eating behavior, including snacking on energy-dense foods instead of fruits and vegetables (Cavadini et al., 1999; Chauliac and deBeco, 1996; Neumark-Sztainer et al., 1998; Sharma, 1998). Consequently there are compelling reasons to develop and implement effective programmes and policies that will increase consumption of fruit and vegetables among children and adolescents.

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doi:10.1016/j.ypmed.2005.11.012

This is, to our knowledge, the first systematic review of the worldwide evidence of interventions to promote children's fruit and vegetable consumption. Earlier reviews were generally limited in scope or geographical setting (Ammerman et al., 2002; Burchett, 2003; Ciliska et al., 1999; Contento, 1995; Miller and Stafford, 2000; Pignone et al., 2003). A number of studies have also been conducted since these reviews were published, creating the need for a new systematic review of fruit and vegetable promotion initiatives worldwide and across all settings.

Materials and methods

A systematic review was conducted to collect and summarize worldwide evidence from published and "grey" literature on current evaluations of all interventions and programmes which promote fruit and vegetable consumption in children and adults (results for adults are reported elsewhere (Pomerleau et al., 2005)).

Criteria for considering studies on children

This review sets out to include all individual and population-based interventions and promotion programmes encouraging consumption of fruit and/or vegetables, where the primary outcome was measured (i.e., change in fruit and/or vegetable intake, derived from self-reported measures or observation, or from availability data—if used as a proxy for intake), provided they followed individuals for at least 3 months, since short-term effects may not be sustained, and medium term changes are more important from a public health perspective. Included were population-based studies (large-scale fruit and vegetable promotions, such as "5-a-day" programmes, nutrition education and information approaches, social marketing approaches) and studies with an individual focus (small-scale and large-scale intervention studies). The intervention had to promote a diet high in fruit and vegetables. This could involve dietary advice taking any form (for example, verbal or written nutrition education, single or multiple contacts with individuals or groups), publicity campaigns, social marketing approaches, or by increasing production such as home gardening.

The following exclusion criteria were applied: (1) the study did not address fruit and vegetable intake; (2) the intervention was not on humans; (3) the report was on acutely ill or institutionalized individuals; (4) follow-up was of less than 3-month duration; (5) the study did not have a control group; (6) the study was multi-factorial and the effect of diet could not be separated out from the other intervention(s); and (7) the primary outcome (fruit and vegetable intake) was not measured.

Search strategy

In April 2004, the following databases were searched from the earliest record: PUBMED, CAB Abstracts, The Cochrane Library, Web of Knowledge, IBSS, Psychinfo (BIDS), EMBASE, AGRICOLA, LILACS, ID21, ERIC, SIGLE, and INGENTA. The search strategy was developed for use in PUBMED and then adapted to the other databases (the precise details of the search strategy are described elsewhere (Pomerleau et al., 2005)).

Selection of documents

Papers published in English, French, Spanish, Portuguese, Russian, Danish, Norwegian, and Swedish were considered. References cited in articles found were also searched, and 139 experts from all regions of the world provided information on unpublished and published projects.

Articles were rejected on initial screening only if the reviewer could determine from the title and abstract that the article was not a report of a fruit and vegetable intervention study or promotion programme, or if any of the exclusion criteria were met. Two reviewers independently assessed study quality and extracted data. A quality assessment tool (http://www.lshtm.ac.uk/ecohost/projects/interventions-fruit-veg.htm) was designed based on those of previous reviews by the Centre for Reviews and Dissemination of the University of York, United Kingdom (Khan et al., 2001), and the previous review by Ciliska et al. (1999). Inter-reviewer agreement was 0.96. It was calculated using percent agreement (Neuendorf, 2002) whereby PA_0 = Total agreements/n (here PA_0 = 74/77 = 0.961). Disagreements between reviewers were resolved by discussion.

Estimation of effect size

The effect size was estimated using one of two methods depending on the data available in the publications:

(1) *Difference between groups in the change in intake*: the difference between groups in the change in intake is the net difference between the change in fruit and vegetable intake in the intervention and control group. A positive difference signifies that the intervention group has a greater increase, or a lower decrease, in fruit and vegetable intake than the control group, comparing intake at baseline and follow-up. It is calculated as = (Follow-up $\text{intake}_{\text{Intervention}}$ − Baseline $\text{intake}_{\text{Intervention}}$) − (Follow-up $\text{intake}_{\text{Control}}$ − Baseline $\text{intake}_{\text{Control}}$).

(2) *Differences between groups at follow-up*: the difference between groups at follow up is reported when studies only report fruit and vegetable intake at follow up. Studies were subdivided into those where the fruit and vegetable intake is higher at follow-up in the intervention or the control group. The difference between groups at follow-up is calculated as = (Follow-up $\text{intake}_{\text{Intervention}}$ − Follow-up $\text{intake}_{\text{Control}}$).

Comparison of study findings

Because of the small number of studies examined and because there was marked heterogeneity in the study populations, types of interventions, and outcome assessment measures, we did not attempt meta-analysis. Findings within age group were compared (primary: 5–12 years and secondary: 13–18 years, school-age) (Table 2) and also according to intervention type namely classroom-based, school-based, teacher involvement, peer leader involvement, school food service staff involvement, parent involvement, policy, community involvement, and length of follow-up (Table 3).

Results

Retrieval of papers

Of the 3499 unduplicated papers identified for review, 306 reported on interventions designed to increase fruit and vegetable intake (Fig. 1). A further 229 papers were excluded as they did not meet our eligibility criteria. Of the remaining 77 articles, 8 were rated as weak on the quality criteria and excluded from the review. Of the final pool of 59 studies (reported in 69 articles), 15 studies (reported in 17 articles) focused on 5- to 18-year-old children and adolescents, the results of which are presented here.

General characteristics of the studies

The general characteristics of the 15 included studies are described in Table 1. Eleven studies targeted primary school-age children and four secondary school children. A majority of studies (80%) came from the United States, and all studies but one included both boys and girls. Follow-up times varied from 3 months to 4 years.

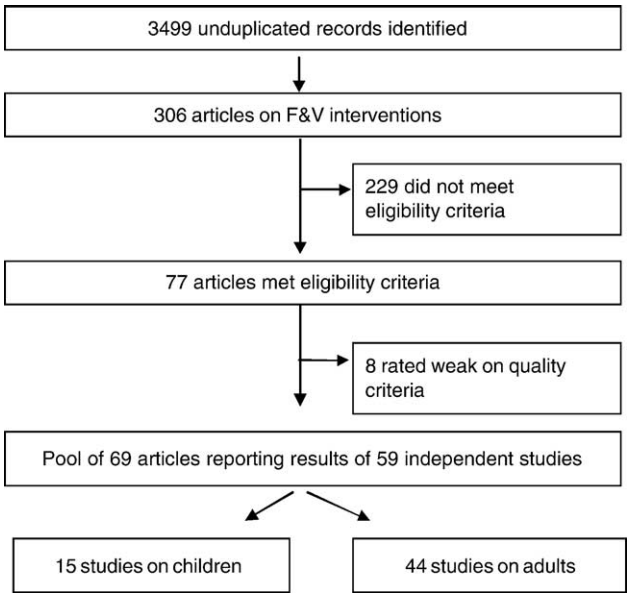

Fig. 1. Selection of papers.

Results by age group

The literature obtained revealed a wide range of interventions and programs promoting fruit and vegetable intake in children, although concentrated in three countries, that have already been performed and assessed. None of the interventions reviewed had a detrimental effect on fruit and vegetable consumption. The details of study design, participants, data collection, intervention type, follow-up length, and results of the 15 included studies are described in Table 2.

Of the eleven studies on primary school children, nine had a significant positive effect on fruit and vegetable consumption, and two did not (Cullen et al., 1997; Lowe and Horne). Of the nine effective studies, seven found that the intervention group had higher intake of fruit and vegetables than the control group at follow-up, the difference ranging from +0.3 to +0.99 servings/day (Auld et al., 1998; Gortmaker et al., 1999a; Perry et al., 1998a, 2004; Reynolds et al., 2000; Sahota et al., 2001); these included one study which calculated the difference at follow-up by percent children in the intervention group having consumed 4 servings/day or more and estimated that 2% had (Friel et al., 1999). Two more studies showed a significant positive net effect: the *5-a-day Power Play! Campaign* showed a net effect of +0.7 servings/day (Foerster et al., 1998), and the *Gimme 5* intervention prevented the overall decrease in consumption that was seen in the control group (net effect +0.3 servings/day) (Baranowski et al., 2000).

Only one of the four interventions in secondary school children showed positive results: in the *Planet Health* intervention, there was a higher increase in fruit and vegetable intake the intervention vs. control group, but only in girls (net effect of +0.32 servings/day) (Gortmaker et al., 1999a). The three other studies *CATCH* (Perry et al., 1998b), *Gimme* 5 (Nicklas et al., 1998), and *TEENS* (Birnbaum et al.,

Table 1
General characteristics of the studies included in the review

	Primary school-aged children (5–12)	Secondary school-aged children (13–18)
Total number of studies (15)	11	4
Countries	Ireland (1), UK (2), US (8)	US (4)
Study design		
Randomized controlled trial	7	4
Non-randomized controlled trial	4	
Number of participants		
Range		
100–499	2	
500–999	4	
≥1000	5	4
Gender		
Boys and girls	10	4
Boys only		
Girls only	1	
Intervention components		
Classroom-based (e.g., integrated curriculum, goal setting)	10	4
School-wide (e.g., increased FV exposure, canteen, family nights)	8	4
Teacher involvement (e.g., training)	8	3
Peer leader involvement	5	1
School food service staff involvement	8	3
Parent involvement	10	3
School food/nutrition policy	1	1
Community involvement (e.g., markets, local media)	5	
Length of follow-up		
3–5 months	3	
6–11 months	1	
12–24 months	5	2
>24 months	2	2
Fruit and vegetable intake measurement (NB some studies used multiple methods)		
Food-frequency questionnaire	3	2
Food record/diary	5	
24-h recall (s)	4	2
Plate waste	1	
Observation	5	
Survey	6	2
Interview	1	
Number of studies with measured effect		
Statistically significant effect		
1) Difference between groups in the change in intake		
–Higher increase in the intervention vs. control group	1	1
–Lower decrease in the intervention vs. control group	1	
–No significant difference	2	1
2) Differences between groups at follow-up		
–Higher intake in intervention group at follow-up	7	
–Higher intake in control group at follow-up		
–No difference at follow-up		2

Table 2
Included studies: description of design, participants, data collection, intervention type, length of follow-up and results

Study	Design	Participants	Data collection	Intervention and control groups; follow-up	Results
Primary school					
Girls scouts eat 5, USA (1)	Randomized controlled trial (pre-test–post test)	22 Junior Girl Scout troops (~300 girls)	Food recognition form (FRF); determinants of food behavior questionnaire (DFBQ)	Intervention: 4 sessions, including fruit and vegetable exposure and preparation skills; goal setting and problem solving; parental involvement. Control: no exposure. follow-up: 3 months	The intervention group increased fruit and vegetable intake at post-test but returned to pre-test levels at the 3 months follow-up. No significant effect
Integrated nutrition project (INP), USA (2)	Randomized controlled trial (Cross-sectional surveys at baseline and follow-up) [years 3 and 4 of a 4-year study '93–'97]	Children in primary school (kindergarten to 5th grade) from three intervention schools and three control schools Year 3: 268 intervention and 181 control; Year 4: 456 intervention and 395 control	Plate waste; food recall/record; classroom survey on knowledge and attitudes to fruit and vegetables; short interview	Intervention: 24 weekly nutrition and food preparation sessions including nutrition education, food preparation; teacher and parent training/ involvement; food resource development. Control: usual curriculum. follow-up: 4 years	Intervention students: significantly higher fruit and vegetable intake ($P < 0.001$), higher levels of nutrition knowledge than the comparison students. The difference between groups at follow-up was ~+0.4 svgs/day
5-a-day power Play! Campaign, USA (3)	Non-randomized, controlled trial	49 schools (151 4th and 5th grades): 15 schools in control group, 19 in intervention T1 and 15 in intervention T2	California Children's Food Survey—A 24-h self-reported food diary	Intervention: over 1 school year, T1: in school *Power Play*! activities; T2: community wide *Power Play*! activities. Control: nutrition education but not *Power Play*! Follow-up: ~1 school year	Intervention groups significantly increased fruit and vegetable intake compared with the control group ($P < 0.001$) (but not compared to each other). Higher increase (vs. control group) in the T2 intervention (~+0.7 svgs/day) than in the T1 intervention (~+0.5 svgs/day)
5-a-day power plus program, USA (4, 5)	Randomized controlled trial (matched-pair design	Children in 4th grade from 20 ethnically, culturally and economically diverse schools	Health behavior questionnaire for all; self-completed 24-h food record for random sample; lunchroom observation	Intervention: behavioral curricula; parental involvement/education; school food service changes; industry involvement and support. Control: usual curriculum. Follow-up: ~10 months	Intervention students had a higher mean intake of fruit and vegetable than control ($P < 0.01$). The difference between groups at follow up was ~+0.4 svgs/day
Nutrition education at primary school (NEAPS), Ireland (6)	Non-randomized, controlled trial	821 children aged 8–10 years from 8 schools in urban and rural areas (453 in intervention; 368 in control)	5-day food diary	Intervention: 20 sessions over 10 weeks including worksheets, homework and exercise regime; parent involvement. Control: usual curriculum. Follow-up: 3 months	Small significant increase in the number of intervention children consuming 4 or more fruit and vegetable per day ($P < 0.01$). Difference between groups at follow-up: 2% of children consumed 4 svgs/day or more
Eat well and keep moving, USA (7)	Non-randomized, controlled trial	Intervention: 6 public elementary schools in Baltimore. Control: 8 matched schools	Food Frequency Questionnaire and 24-h recall	Intervention: classroom-based intervention; food school services and families involved. Control: usual curriculum. Follow-up: 2 years	There was a significant increase in fruit and vegetable intake ($P = 0.01$). The difference between groups at follow up was ~+0.73 svgs/day

Table 2 (*continued*)

Study	Design	Participants	Data collection	Intervention and control groups; follow-up	Results
Gimme 5, USA (8)	Randomized controlled trial	1253 children in 4th and 5th grade from 16 elementary schools	7-day food record	Intervention: 12 sessions over 6-week including handouts, posters, work sheets, newsletters, videos; point of purchase education at shops. Control: usual curriculum. Follow-up: 3 years	Lower decrease in the intervention vs. control group: net effect of +0.3 svgs/day
High 5 project, USA (9)	Randomized controlled trial (matched-pair design)	28 elementary schools pair-matched based on ethnic composition and proportion of students receiving free or reduced-price meals	Children: 24-h recall and cafeteria observation. Parents: Food Frequency Questionnaire	Intervention: 14-lesson curriculum delivered on 3 consecutive days each week. There were three intervention components: classroom, parent and food service. Control: usual curriculum. Follow-up: 2 years	Intervention group had higher intakes of fruit and vegetables ~+0.99 svgs/day at 2 years ($P < 0.0001$)
APPLES: Active programme promoting lifestyles in schools, UK (10)	Randomized controlled trial (randomization of schools)	636 children aged 8–10 years from 10 primary schools in Leeds (314 intervention, 322 controls)	24-h recall, and 3-day food diary	Intervention: 1 year including Teacher training, school meals changes, curriculum development, physical education, tuck shops. Control: usual curriculum. Follow-up: 12 months	Intervention children had increased intake of vegetables by ~+0.3 svgs/day but no significant change in fruit intake
Food dude healthy eating programme, UK (11)	Non-randomized controlled trial	Children aged 5–7 years inform 2 low income primary schools (364 in intervention; 384 in control)	Lunchtime and snack fruit and vegetables were observed and weighed. Parents: questionnaire about child's home intake	Intervention: 16-day programme and 10-week maintenance phase including increased fruit and vegetable supply; video where older peers 'Food Dudes' extol the benefits of eating a number of fruit and vegetables. Control: usual curriculum. follow-up: 2 years	Lunch fruit and vegetable significantly higher at follow-up; at snack time, fruit intake increased but returned to baseline levels at follow-up. Non-significant overall change in all groups
5-a-day cafeteria power plus project, USA (12)	Randomized controlled trial	1668 students in 1st and 3rd grades from 26 elementary schools	Observations by trained staff	Intervention: School food service involvement; daily activities and special fruit and vegetable events like fruit and vegetable competition. Control: usual curriculum. Follow-up: 2 years	Significant increase of fruit and vegetable in take ($P = 0.02$). Verbal encouragement by lunch staff significantly associated with higher intakes. Difference between groups at follow-up was ~+0.3 svgs/day
Secondary school					
Gimme 5, USA (13)	Randomized controlled trial (matched-pair design); longitudinal intervention	9th Grade students (followed through 12th grade) in 12 schools (6 pairs)	The Knowledge, Attitudes and Practices questionnaire	Intervention: Gimme 5 measurement questionnaire + intervention including school-wide media marketing campaign; school meal modification; parental involvement. Control: Gimme 5 measurement questionnaire only. Follow-up: 3 years	No difference at follow-up

(*continued on next page*)

Table 2 (*continued*)

Study	Design	Participants	Data collection	Intervention and control groups; follow-up	Results
Child and adolescent trial for cardiovascular health (CATCH), USA (14)	Randomized controlled trial	1186 primary school students, i.e. a sub-sample of the 5106 students in the original CATCH study who had participated in single 24-h food recalls at baseline and were recruited for a follow-up recall in the 5th grade	24-h recalls at baseline and follow-up; 30-min face to face interviews at baseline and follow-up	Intervention: including modifications in school food service, physical education, classroom curricula and parental involvement. Control: usual curriculum. Follow-up: 3 years	No difference at follow-up
Planet health, USA (7)	Randomized controlled trial	Children in grades 6–8 from 10 public schools from 4 communities in Boston (MA)	Food and activity survey and youth FFQ	Intervention: including teacher training; classroom lessons; physical education materials; wellness sessions and fitness funds. Control: usual curriculum. Follow-up: 2 years	Higher increase in the intervention vs. control group (~+0.32 svgs/day) but only in girls ($P = 0.003$)
TEENS-teens eating for energy and nutrition at school, USA (15, 16)	Randomized controlled trial	16 schools with at least 20% of students approved for free and reduced-priced lunch, and with at least 30 students in each of 7th and 8th grades	24-h recalls Student survey and fruit and vegetable screener	Intervention: 4 groups: Group 1 (control); Group 2 school environment interventions only; Group 3, as 2 but with classroom lessons; Group 4, as 3 but with peer leaders (including taste testing, increasing availability of fruit and vegetables, posters, prize raffles; classroom curriculum, parent packs. Control (Group 1): usual curriculum. Follow-up: 2 years.	Significant increase in intervention Group 4 (~+0.9 svgs/day) ($P = 0.012$) at interim evaluation but no significant effect at 2-year follow up

2002; Lytle et al., 2004) had non-significant results at follow up.

Results by other characteristics of the studies

Results were also examined according to study design and intake measurement method. Out of the 15 studies, 11 were randomized controlled trials (RCTs) and 4 were non-randomized controlled trials (non-RCTs). The proportion of interventions reporting significant effects did not differ according to study design (73% of RCTs and 75% of non-RCTs showed significant differences between groups). In terms of intake measurement methods, two out of the three most effective interventions (Foerster et al., 1998; Gortmaker et al., 1999b; Reynolds et al., 2000) used a combination of Food Frequency Questionnaires and 24-h recall, and two also used observation (Foerster et al., 1998; Reynolds et al., 2000). *High 5* and *Eat Well* interventions presented results by measurement method and found that 24-h recall yielded significant results, but that the FFQ was significant only in one of the interventions (*Eat Well*). Observation in *High 5* yielded non-significant results. These findings and the small number of studies they are based on make it difficult to draw conclusions about differences associated with measurement tools.

Results by intervention component

The major intervention components and the estimated effect of the 15 studies included are described in Table 3. A few qualitative observations can be made based on the interventions within effective studies although these interpretations could not be directly and systematically tested. Specifically, it appears that the following intervention components are associated with successful results (not in order of importance): particular attention to fruit and vegetables rather than to nutrition in general (e.g., integrated into the usual curriculum; promoted in the canteen and around school, e.g., on posters); hands-on exposure to fruit and vegetables, for example, by developing preparation skills and taste testing (as opposed to traditional lectures); special training of teachers; peer leaders (student leaders, fictional cartoon characters); active participation and encouragement by school food service staff (verbal encouragement by the school food service staff to choose fruit and vegetables was associated with significantly higher intakes on at least one occasion (Perry et al., 2004)); active involvement

of parents at school and at home; development of a school nutrition policy, ideally through established advisory committees; community involvement (participation of local fruit and vegetable industry (producers, markets) as well as youth and service organisations); length of follow-up (in general – but not always – the longer the follow-up, the more successful the intervention).

Table 3 reveals a similar pattern of components across studies, making it difficult to draw conclusions about which combinations of components may be most effective. However, a closer look at the three most effective reviewed studies (Foerster et al., 1998; Gortmaker et al., 1999b; Reynolds et al., 2000) suggests that the more students are exposed to fruit and vegetables, the more the consumption patterns improve. In the *5-a-day Power Play! Campaign*, there were two levels of intervention: school only and a more intensive school + community exposure. Fruit and vegetables intake increases were highest for the intervention group with the most intensive exposure (independent work in classrooms, canteens and with families, community youth organization activities, point-of-purchase education and promotion in produce markets, public service announcements on local television stations, fruit and vegetable promotion competitions sponsored by the local fruit and vegetable industry) (Foerster et al., 1998). The *High 5* intervention also had a multicomponent approach where students in the classroom, parents, and the food service staff were not only involved but required to provide feedback and evaluation. The parents' dietary behavior was also assessed, and intervention effects for parents were significant, leading authors to suggest that "parents who alter their consumption will likely [. . .] modify the home environment to make fruit and vegetables available for the children" (Reynolds et al., 2000). The *Eat Well and Keep Moving* intervention was mainly classroom based but linked the curriculum to the school food service, and teacher and family involvement. Of particular note is the fact that the school provided links with local organisations in the community which offered low-cost nutrition and physical activity programmes for the parents (Gortmaker et al., 1999b). The three most effective interventions all lasted at least 12 months (Foerster et al., 1998; Gortmaker et al., 1999b; Reynolds et al., 2000).

Although the final results were non-significant (Lytle et al., 2004), interim results of the TEENS intervention (Birnbaum et al., 2002) were very promising (~+0.9 servings/day), in part explained by the same combination: those with the greatest exposure to intervention components (in this case, the peer leaders) consistently showed the greatest improvement in fruit and vegetable consumption. Intervention components included helping teachers deliver classroom interventions and leading small group discussion about fruit and vegetables and participating in the School Nutrition Advisory Council, which comprised staff, parents, and student representatives. In fact, the lack of peer leaders during the second year was cited as a possible reason for the lack of effectiveness of the TEENS intervention at follow-up (Lytle et al., 2004). Other reasons for unsuccessful interventions might include very short intervention and follow-up periods such as in the *Girl Scout Eat 5* intervention (Cullen et al., 1997) or a lack of focus specifically on fruit and vegetables in studies originally addressing other issues, as in the *CATCH* study (Perry et al., 1998b).

Discussion

The findings of this review contribute to the growing body of evidence of how best to promote fruit and vegetable in the critical age group of children and adolescents. Of the fifteen studies reviewed, ten had a significant effect, ranging from +0.3 to +0.99 servings/day. Translated into broad population interventions and optimizing the most effective intervention components, such change in fruit and vegetable intake could have an important long-term public health impact, particularly in terms of reducing non-communicable diseases (IARC, 2003; Klerk et al., 1998; Robertson et al., 2004; WCRF/AICR, 1997; WHO, 2003).

Although the review set out to obtain a worldwide understanding of fruit and vegetable promotion in children and adolescents, the studies meeting the stated criteria only represent a very small subsample of developed countries. Thus, the results are mostly relevant to developed countries but are certainly useful as a means to inform the design of evaluations of intervention programmes to promote fruit and vegetable consumption in all geographical and socioeconomic settings, provided they are appropriately adapted to particular needs (e.g., non-school based approaches in developing countries—such as the home-based food production programme described by Faber et al. (2002)).

All but one intervention were school based. This setting provides many opportunities to improve nutrition: formal learning, as well as gardening, cooking, and feeding (Chauliac et al., 1996). School-based health and nutrition programmes and feeding programmes can be practical, implemented at low cost and may also encourage children and adolescents to remain in school. (Jacoby et al., 1998; Simeon, 1998; SCN, 2002).

Although the evidence reviewed here is very diverse and based on a relatively small number of studies performed in selected developed countries (thus limiting the generalizability of the conclusions on effectiveness), the findings highlight some intervention components that are particularly important to the success of an intervention in this setting. These include duration of at least 12 months; increase exposure to fruit and vegetables among the whole school community; include teacher training and integrate within the curriculum; include leadership and encouragement by peers and the school food service staff; and involve parents at school and at home. The benefits of a comprehensive, multifaceted approach are in accordance with another systematic review that looked more broadly at health promotion in schools (Lister-Sharp et al., 1999).

Barriers to change in children and adolescents include individual barriers (e.g., erratic eating behavior s) and environmental barriers (omnipresent marketing of fast food,

Table 3
Details of the intervention components in each review study

Study reference Intervention component	High 5 (9)	Eat Well (17)	5 a Day PPlay (3)	INP (2)	5 a Day PP (4, 5)	Planet Health (7)	Apples (10)	5 a Day Caf. PP (12)	Gimme 5 (8)	Neaps (6)	Gimme 5 (13)	Catch (14)	Girl Scouts (1)	Food Dudes (11)	Teens (15, 16)
EFFECT (servings/day)	DFU 0.99[a]	DFU 0.73	DBG 0.7	DFU 0.4	DFU 0.4	DBG 0.32	DFU 0.3[b]	DFU 0.3	DBG 0.3	DFU 2%[c]	N-DFU	N-DFU	NS	NS	NS
In the classroom															
Integrated into curriculum including FV preparation		X	X	X	X	X				X		X		X	X
Prize /competition as incentive (for class team or student)		X	X					X	X		X		X		
Goal setting/problem solving/ skill building	X			X	X	X			X				X		
Self evaluation, e.g., food diaries	X			X						X			X		
Extracurricular workshops											X				
In the school															
Increased exposure to FV, e.g., in canteen, on posters, taste testing, announcements	X	X	X		X			X	X		X		X[d]		X
Limited TV viewing campaigns		X				X									
Family nights				X					X			X			
Teachers involvement															
Training, workshops	X	X	X	X	X	X	X			X	X		X		X
Peer leaders involvement															
Student/fictional leaders	X				X			X		X				X	X
School food service staff involvement															
Lunch/snacks modifications	X	X	X		X		X	X			X	X	X		X
Training/ encouragement by	X	X	X	X	X		X	X			X				X
Parents involvement															
Information sheets/newsletters	X		X	X	X		X		X	X	X	X	X	X	
Sheets/Newsletters															
Activity /snack packs at home	X	X	X		X		X		X	X	X	X	X		X
Teaching /advisory role				X											X
Policy															
Health promoting school approach							X								
School nutrition council /policy							X								X
Community involvement															
Producers/markets participation			X		X				X						

Table 3 (*continued*)

Study reference Intervention component	High 5 (9)	Eat Well (17)	5 a Day PPlay (3)	INP (2)	5 a Day PP (4, 5)	Planet Health (7)	Apples (10)	5 a Day Caf. PP (12)	Gimme 5 (8)	Neaps (6)	Gimme 5 (13)	Catch (14)	Girl Scouts (1)	Food Dudes (11)	Teens (15, 16)
EFFECT (servings/day)	DFU 0.99[a]	DFU 0.73	DBG 0.7	DFU 0.4	DFU 0.4	DBG 0.32	DFU 0.3[b]	DFU 0.3	DBG 0.3	DFU 2%[c]	N-DFU	N-DFU	NS	NS	NS
Community involvement															
Local nutrition ed. for parents/ targeted at markets		X	X	X					X						
Local media (TV/radio)			X												
Youth/voluntary organizations			X												
Length of follow-up															
3–5 months										X			X	X	
6–11 months					X										
12–24 months	X	X	X			X	X	X							X
>24 months				X					X		X	X			
Fruit and vegetable intake measurement															
Food frequency questionnaire	X	X				X							X		X
Food record/diary			X	X			X		X	X					
24-h recall	X	X			X		X					X			X
Plate waste				X											
Observation	X		X		X			X						X	
Survey			X	X	X	X				X	X		X	X	
Interview				X											

Notes. DBG—difference between groups in the change in intake; DFU—difference between groups at follow-up; N-DFU—no difference at follow-up; NS—no significant effect.

[a] At 2 years.

[b] Significant in vegetable intake only.

[c] The difference at follow-up was 2% of children in the intervention group consumed 4 servings/day or more.

[d] This study was not school-based but did have increased exposure to fruit and vegetables, e.g., through taste testing and food preparation.

poor access, and/or high cost of fruit and vegetables) (Cavadini et al., 1999; Chauliac and deBeco, 1996; Hastings et al., 2005; Neumark-Sztainer et al., 1998, 2003; Sandvika et al., 2005; Sharma, 1998). Barriers to school-based interventions include competition against other school priorities. Nutrition is not seen as a priority in increasingly crowded curricula. Furthermore, some interventions could be perceived as too demanding or may gain insufficient support due to poor coordination and communication between key actors (teachers, school staff, parents) (e.g., Cho and Nadow, 2004).

This review has several limitations. First, some studies may have been missed although the bibliographic search was extensive and 139 experts were consulted. Second, interventions that lacked a control group were not evaluated, and those that did not provide data on fruit and vegetable intake were excluded. These studies were from developing countries and/or national or large-scale promotion interventions. For example, Faber et al. (2002) reported on a home gardening intervention that targeted vegetable consumption. It was excluded because only changes in micronutrient consumption were reported, not total fruit and vegetable intake, but it is an interesting example of a non-school-based intervention. Third, the main outcome measure was, in most cases, obtained from self-reports and is thus subject to the limitations of self-reported dietary assessment methods, particularly when measuring small changes in dietary intake. Fourth, follow-up periods were relatively short so long-term sustainability could not be examined. Fifth, the risk of relapse to lower intakes (which may include seasonal availability of fruit and vegetable) was not examined. Sixth, the cost of interventions was not addressed. Finally, it is impossible to exclude the possibility of publication bias, with negative findings not being reported.

Conclusion

Lessons learned from other areas of public health (e.g., Swinburn et al., 2004) point to the importance of creating an enabling environment within which public health can be promoted. It is important that an enabling environment for fruit and vegetable consumption by children be generated. This might include a range of macro-level interventions such as increasing access to fruit and vegetables through targeted government subsidies of production; agricultural policies that support healthy diets (Schafer-Elinder et al., 2003); supporting access to affordable fruit and vegetable markets (WHO, 2001); adequate funding and policies for schools to provide adequate school food services including local fresh fruit and vegetables (NHS, 2002), reduced access to ‘junk food’ in

schools to make the "healthier choice" easier for children (James et al., 2004), and consistent practice (at least in the school) of nutrition education lessons.

More research is needed to examine in more depth, and for longer follow-up periods, the effectiveness and cost effectiveness of interventions promoting fruit and vegetable consumption. Developing countries should be encouraged and supported to design, conduct, and evaluate robust fruit and vegetable promotion interventions. Any new project or initiative should have evaluation included as part of the project plan. Furthermore, what constitutes a meaningful change in intake should be examined, as should the effectiveness of specific components of interventions, and how these vary by country. Finally, barriers to effectiveness must be assessed and taken into consideration to maximise the success of future interventions.

Acknowledgments

Ms Ingrid Keller and Ms Vanessa Candeias at the World Health Organization are sincerely thanked for their support and help with identifying experts and obtaining research papers, and the contribution of the many people world wide who helped with this review by supplying information is gratefully acknowledged. This review was funded by the World Health Organization. However, WHO cannot accept any responsibility for any information provided or views expressed. The authors have no conflict of interest.

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